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STATE OF ALASKA

Bill Sheffield, Governor

Annual Performance Report for

A STUDY OF LAND USE ACTIVITIES AND THEIR RELATIONSHIP TO THE SPORT FISH RESOURCES IN ALASKA

by

Mark W. Schwan

ALASKA DEPARTMENT OF FISH AND GAME
Don W. Collinsworth, Commissioner

DIVISION OF SPORT FISH
E. Richard Logan, Director

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RESEARCH PROJECT SEGMENT

State: Alaska

Name: Sport Fish Investigations of Alaska

Project: F-9-17

Study: D-I

Study Title: A STUDY OF LAND USE ACTIVITIES AND THEIR RELATIONSHIP TO THE SPORT FISH RESOURCES IN ALASKA

Job: D-I-A

Job Title: TLMP; Agency Fisheries Coordination

Cooperator: Mark W. Schwan

Period Covered: July 1, 1984 to June 30, 1985

ABSTRACT

A project was begun to computerize fisheries data contained within the Division of Sport Fish's stream and lake files. Geographic, land status, and fish resource data for more than 800 lakes and streams were entered on the hard disc of an IBM PC-XT microcomputer. Sequential and random access file formats were used. A variety of BASIC programs were written for file maintenance and data retrieval. Several "user friendly" programs were written for general data access by regional staff.

A draft report was written regarding the effects of logging on fish resources. This report was forwarded to the Department of Fish and Game's Habitat Division for inclusion in a departmental report dealing with the effects of logging on fish, wildlife, and the users of these resources. This report is being prepared at the same time the U.S. Forest Service is preparing a status report [706(b) report] on the Tongass National Forest, 5 years after the passage of the Alaska National Interest Lands Conservation Act (ANILCA).

KEYWORDS

Tongass, TLMP, ANILCA, Sport Fish, planning, 706(b), U.S. Forest Service, habitat, logging, timber, database, computers, inventory, lakes, streams, Southeast, Alaska, programming, BASIC, recreation, fisheries.

BACKGROUND

The Tongass Land Management Plan (TLMP) will be revised in 1989. This plan, which is the primary management prescription for most of southeast Alaska's fisheries habitat, is crucial to the future of the region's fisheries resources. The U.S. Forest Service has already begun working on the revision, although efforts will increase in 1986.

When the Alaska National Interest Lands Conservation Act (ANILCA) was passed in 1980, one of the most controversial sections was the national forest timber utilization program (Section 705). It was specified therein that the Secretary of the Treasury shall make available to the Secretary of Agriculture the sum of 40 million dollars annually, or as much as the Secretary of Agriculture deems necessary, to maintain a timber supply from the Tongass National Forest to dependent industry at a rate of 4.5 billion board feet per decade.

Section 706(b) of ANILCA required that within 5 years, the U.S. Forest Service (USFS), in cooperation with the State of Alaska, affected Native Corporations, the Southeast Alaska timber industry, the Southeast Alaska Conservation Council, and the Alaska Land Use Council, prepare a report to Congress on the status of the Tongass National Forest. The Regional Forester recommended in 1984 that cooperating agencies and organizations would be wise to prepare their own documents in response to the 706(b) mandate in lieu of solely attempting to shape the Forest Service's report to their liking. The Alaska Department of Fish and Game (ADF&G) decided to do just that. The current date for completion of the Department's report is May, 1985. The Forest Service plans to submit their 706(b) report to Congress by December 1985.

Given the increasing planning activities within and outside of the Department, and especially given the upcoming revision of the TLMP, the Region I Sport Fish Staff believed it critical that fisheries data be better organized and a computerized database system be developed to allow rapid and more complete participation in regional planning efforts. This will enhance our abilities to respond properly to future planning decisions and help assure protection of valuable fisheries resources.

Table 1 lists the common name, scientific name, and abbreviation for each fish species mentioned in this report.

RECOMMENDATIONS

Management: Develop a departmental comprehensive recreational fisheries plan for southeast Alaska.

Research: Continue to develop a computerized stream and lake database.

OBJECTIVES

1) To develop a readily accessible computerized database which will include all pertinent information available

Table 1. List of common names, scientific names, and abbreviations.

COMMON NAME	SCIENTIFIC NAME & AUTHOR	ABBREV.
Pink salmon	*Oncorhynchus gorbuscha* (Walbaum)	PS
Chinook salmon	*Oncorhynchus tshawytscha* (Walbaum)	KS
Chum salmon	*Oncorhynchus keta* (Walbaum)	CS
Coho salmon	*Oncorhynchus kisutch* (Walbaum)	SS
Sockeye salmon	*Oncorhynchus nerka* (Walbaum)	RS
Kokanee	*Oncorhynchus nerka* (Walbaum)	KK
Dolly Varden	*Salvelinus malma* (Walbaum)	DV
Rainbow trout	*Salmo gairdneri* Richardson	RB
Steelhead trout	*Salmo gairdneri* Richardson	SH
Cutthroat trout	*Salmo clarki* Richardson	CT
Brook char	*Salvelinus fontinalis* (Mitchell)	BT
Arctic grayling	*Thymallus arcticus* (Pallas)	GR

regarding existing or potential sport fisheries in Southeast Alaska.

2) To participate in multiple agency planning activities in order to identify and protect existing and potential sport fisheries in Southeast Alaska.

TECHNIQUES USED

1) Database Development

A primary lake and stream data file was created, with 22 fields (variables) per record. There are currently 830 records in this file. Variables include the name of the lake or stream, map reference, latitude, longitude, VCU, LUD, anadromous stream number, 12 species fields, presence of USFS recreational cabins, and a record number.

The data entry sheets were coded and taken to Woolfe and Associates for key punching onto 8½" floppy diskette. The diskette was taken to the State of Alaska Computer Center and the data were loaded onto the State's IBM mainframe computer.

Once data were on the State computer, the file was edited, sorted, and then downloaded to the IBM PC-XT microcomputer in the Division of Sport Fish's Southeast regional office. The file was then further edited with Personal Editor. PC-Talk was used to transmit the data file from the State computer to the microcomputer.

Programs written in BASICA were developed for outputting data. One program was written in a "user friendly" format such that anyone, regardless of programming ability, can run the program and access information from the data files. Because the regional file is in sequential format, it takes more than three minutes for the program to search the file. Therefore, smaller, area files (Juneau, Yakutat, Admiralty Island, etc.) were created and programs rewritten to give the user the option to search these files, when appropriate, to shorten the time for data retrieval.

Many small BASIC programs were written to expedite file maintenance and data retrieval. Additionally, a variety of commercial software packages were reviewed for possible use on the microcomputer with the stream and lake data files. All programs and files were backed up twice on separate floppy diskettes and backups were always updated after any revisions were made to the working files and programs.

2) TLMP Coordination

Drafts of the TLMP evaluation report were reviewed and comments were forwarded to the Habitat Division. Drafts of the Forest Service's 706(b) Report Study Plan were reviewed, as was the Department's own study plan for an independent 706(b) report.

The fisheries sections of the Department's 706(b) report were the primary responsibility of the Division of Sport Fish, however, the Division of Commercial Fisheries also contributed a portion of the draft. The four major subject areas discussed in the fisheries draft were: 1) environmental variables important to fish production that are affected by timber harvest activities, 2) short term impacts of fish populations from timber harvest, 3) long term impacts on fish populations from timber harvest, and 4) effects of timber harvest on users of fish resources.

The short and long term impacts on pink and chum salmon and the effects on commercial users were written by John Edgington of the Division of Commercial Fisheries (A.D.F.& G.). Short term and long term impacts on other salmonid species were written by Steve Elliott of the Division of Sport Fish (A.D.F.& G.). The discussion of important environmental variables and the effects on recreational users were written by the author. This individual was also responsible for revising and editing the completed draft before it was forwarded to the Habitat Division.

FINDINGS

1) Database:

The data now on the microcomputer represent the minimal essential information on the most important sport fishing waters in southeast Alaska. In the coming months, other data sets, such as stocking histories, limnological analyses, and species abundance, will be compiled and entered on the computer. Many more waters will be included.

It appears that BASIC programs will satisfactorily access and output the kinds of data most often in demand by the Sport Fish staff. However, most data files are in a sequential format and program searching is rather slow. As files become longer, this may become a significant problem. Random ("direct" record access) file formats may offer a more efficient method of retrieval, however, this format may not be compatible with data searching needs.

BASIC is weak regarding sorting. It is likely that a commercial database management software package will be purchased that has easy-to-use and powerful sorting capabilities. Appendix A includes an example of one of the BASIC programs written to access and output stream and lake information.

2) TLMP Coordination:

Virtually all efforts related to this activity went toward drafting a report dealing with the effects of logging on fish resources. Appendix B is a copy of Sport Fish's working draft that was submitted to Habitat Division. The Division of Sport Fish will review the entire departmental report sometime in May 1985. The report prepared by A.D.F.& G. was originally intended to be a technical appendix to a larger State of Alaska report, aimed at addressing issues that might not be discussed in the Forest Service's 706(b) report to Congress. However, there will be no state report and the A.D.F.& G. document will be treated as an information document, to be distributed upon request.

Appendix A.

```
10 CLS
20 LOCATE 8,1
30 PRINT "*******************************************************************"
40 LOCATE 12,1
50 PRINT "                 LAKE AND STREAM INVENTORY PROGRAM "
60 PRINT:PRINT:PRINT
70 PRINT "             BY  M.W.SCHWAN        VERSION:    MAY 6, 1985"
80 PRINT "*******************************************************************"
90 PRINT:PRINT
110 PRINT "                 DO YOU NEED INSTRUCTIONS? (Y OR N)"
120 PRINT:PRINT
170 K$=INKEY$: IF K$="" GOTO 170
180 IF ASC(K$)=89 OR ASC(K$)=121 THEN GOTO 200
190 IF ASC(K$)=78 OR ASC(K$)=110 THEN GOTO 820 ELSE GOTO 170
200 CLS:LOCATE 8,1
210 PRINT "           THIS PROGRAM ACCESSES STREAM AND LAKE FILES WHICH"
220 PRINT "           INCLUDE MOST OF THE IMPORTANT SPORT FISHING LAKES"
230 PRINT "           OF SOUTHEAST ALASKA, INCLUDING YAKUTAT. THEY ALSO INCLUDE"
240 PRINT "           NEARLY 400 STREAMS, MOST OF WHICH ARE KNOWN TO CONTAIN"
250 PRINT "           STEELHEAD AND OR SPAWNING STOCKS OF SEA-RUN CUTTHROAT."
260 PRINT
270 PRINT "           THESE FILES WILL BE CONTINUALLY EXPANDED TO INCLUDE"
280 PRINT "           ADDITIONAL STREAMS AND LAKES."
290 PRINT
300 PRINT "           THERE ARE TWO MAJOR PARTS TO THIS PROGRAM.  THE FIRST"
310 PRINT "           ALLOWS THE USER TO ENTER THE NAME OF A LAKE OR STREAM"
320 PRINT "           AND THE COMPUTER SEARCHES FOR THAT NAME AND DISPLAYS"
330 PRINT "           BASIC INFORMATION ABOUT THE WATER, INCLUDING LOCATION,"
340 PRINT "           OWNERSHIP STATUS, AND SPECIES OCCURANCE."
350 PRINT
360 PRINT
370 PRINT
380 PRINT TAB(20) "HIT THE SPACE BAR TO CONTINUE"
390 K$=INKEY$: IF K$="" GOTO 390
400 IF ASC(K$)=32 THEN GOTO 410 ELSE GOTO 390
410 CLS
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420 LOCATE 8,1
430 PRINT "          IF A STREAM OR LAKE FALLS WITHIN MORE THAN ONE OWNERSHIP"
440 PRINT "          STATUS, AND OR DIFFERENT LAND USE DESIGNATION (LUD), THEN"
450 PRINT "          MULTIPLE RECORDS WILL EXIST FOR THESE WATERS.  AFTER THE"
460 PRINT "          COMPUTER FINDS A MATCH AND DISPLAYS THE OUTPUT, THE"
470 PRINT "          PROGRAM WILL STOP RUNNING AND WILL ASK FOR PROMPTS FROM"
480 PRINT "          THE USER TO CONTINUE SEARCHING OR ELSE GO BACK TO COMMAND"
490 PRINT "          LEVEL TO RUN THE PROGRAM AGAIN OR EXIT BASIC.
500 PRINT
510 PRINT "          THE OTHER PART OF THIS PROGRAM PRESENTS A SPECIES MENU"
520 PRINT "          FOR THE USER AND ALLOWS THE USER TO GET A LIST OF ALL"
530 PRINT "          WATERS IN DIFFERENT AREAS OF SOUTHEAST ALASKA THAT CONTAIN
540 PRINT "          A CERTAIN SPECIES."
550 LOCATE 22,20:PRINT "HIT THE SPACE BAR TO CONTINUE"
560 K$=INKEY$: IF K$="" GOTO 560
570 IF ASC(K$)=32 GOTO 580 ELSE GOTO 560
580 CLS
590 LOCATE 8,1
600 PRINT "          THIS PROGRAM DOES NOT AUTOMATICALLY SEND ANY OUTPUT TO"
610 PRINT "          THE PRINTER.  IF YOU WANT A HARD COPY OF THE OUTPUT THEN"
620 PRINT "          YOU MUST PRESS THE (CTRL) KEY AND WHILE KEEPING THAT KEY"
630 PRINT "          DEPRESSED, PUSH THE PRINT SCREEN (PRTSC) KEY.  THIS KEY"
640 PRINT "          COMBINATION SERVES AS A TOGGLE SWITCH (ON/OFF) FOR"
650 PRINT "          ACTIVATION OF THE PRINTER.  WHILE ON, ANYTHING YOU TYPE"
660 PRINT "          AND ANY OUTPUT DISPLAYED ON THE SCREEN WILL BE PRINTED."
670 PRINT "          MAKE SURE THE PRINTER IS ON, PROPERLY SET, AND LOADED"
680 PRINT "          WITH PAPER.
690 PRINT
700 PRINT "          IF THIS PROGRAM DOES NOT GIVE YOU THE RESULTS YOU NEED,"
710 PRINT "          THERE IS ANOTHER PROGRAM THAT CAN BE EASILY EDITED TO"
720 PRINT "          EXTRACT MOST LIKELY ANY ARRANGEMENT OF DATA YOU MIGHT"
730 PRINT "          WANT.  IF THIS IS THE CASE, SEE MARK SCHWAN.  WHEN YOU"
740 PRINT "          ARE DONE WITH THIS PROGRAM AND WANT TO TERMINATE"
750 PRINT "          OPERATION, TYPE 'SYSTEM' AND THEN HIT A <CR>.  YOU"
760 PRINT "          SHOULD THEN SEE THE C> PROMPT ON THE SCREEN."
770 PRINT
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780 PRINT
790 PRINT
800 PRINT TAB(20) "HIT THE SPACE BAR TO CONTINUE"
810 K$=INKEY$: IF K$="" GOTO 810
820 CLS
830 PRINT
840 LOCATE 8,1
850 LET Q=0
860 PRINT "          DO YOU WANT INFORMATION FOR A SPECIFIC LAKE OR STREAM,"
870 PRINT "          OR DO YOU WANT A LIST OF WATERS THAT CONTAIN A CERTAIN"
880 PRINT "          SPECIES OF FISH?"
890 PRINT
900 PRINT "          IF YOU ARE INTERESTED IN A SPECIFIC LAKE OR STREAM, THEN"
910 PRINT "          ENTER THE NAME; DO NOT INCLUDE THE WORDS LAKE OR STREAM."
920 PRINT "          IF, INSTEAD, YOU WANT A LISTING OF WATERS THAT CONTAIN"
930 PRINT "          A CERTAIN SPECIES, TYPE GO, AND YOU WILL GO TO THE PART"
940 PRINT "          OF THE PROGRAM TO GET THIS TYPE OF INFORMATION."
950 LOCATE 18,34:INPUT E$
970 LE=LEN(E$)
980 FOR I=1 TO LE:ASCY%=ASC(MID$(E$,I,1))
990 IF ASCY%>96 THEN MID$(E$,I,1)=CHR$(ASCY%-32)
1000 NEXT I
1010 IF E$="GO" GOTO 2380
1020 CLS:PRINT:PRINT:PRINT
1030 PRINT TAB(11) "IF YOU KNOW WHICH AREA TO SEARCH FOR THE DESIRED LAKE"
1040 PRINT TAB(11) "OR STREAM, ENTER THE APPROPRIATE AREA CODE.  IF YOU DO"
1050 PRINT TAB(11) "NOT KNOW WHICH AREA FILE TO SEARCH, THEN ENTER NUMBER 1"
1060 PRINT TAB(11) "FOR SEARCHING THE SOUTHEAST, REGIONAL FILE."
1070 PRINT
1080 PRINT TAB(18) "ALL OF SOUTHEAST ALASKA - - - - - 1"
1090 PRINT TAB(18) "ADMIRALTY ISLAND AREA - - - - - - 2"
1100 PRINT TAB(18) "BARANOF ISLAND AREA - - - - - - - 3"
1110 PRINT TAB(18) "CHICHAGOF ISLAND AREA - - - - - - 4"
1120 PRINT TAB(18) "JUNEAU MAINLAND AREA  - - - - - - 5"
1130 PRINT TAB(18) "HAINES/SKAGWAY AREA - - - - - - - 6"
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1140 PRINT TAB(18) "KETCHIKAN AREA  - - - - - - - - - 7"
1150 PRINT TAB(18) "PETERSBURG AREA - - - - - - - - - 8"
1160 PRINT TAB(18) "PRINCE OF WALES ISLAND AREA - - 9"
1170 PRINT TAB(18) "STEPHENS PASSAGE MAINLAND AREA-10"
1180 PRINT TAB(18) "WRANGELL AREA - - - - - - - - - -11"
1190 PRINT TAB(18) "YAKUTAT AREA  - - - - - - - - - -12"
1200 PRINT:PRINT:PRINT
1210 LOCATE 22,35:INPUT CC
1220 CLS
1230 ON CC GOTO 1240,1250,1260,1270,1280,1290,1300,1310,1320,1330,1340,1350
1240 OPEN "I",#1,"ALANA.PRN": GOTO 1360
1250 OPEN "I",#1,"ADMIRALT": GOTO 1360
1260 OPEN "I",#1,"BARANOF": GOTO 1360
1270 OPEN "I",#1,"CHICH": GOTO 1360
1280 OPEN "I",#1,"JUNEAU": GOTO 1360
1290 OPEN "I",#1,"HNSSK": GOTO 1360
1300 OPEN "I",#1,"KETCH": GOTO 1360
1310 OPEN "I",#1,"PSG": GOTO 1360
1320 OPEN "I",#1,"POW": GOTO 1360
1330 OPEN "I",#1,"STEPHPAS": GOTO 1360
1340 OPEN "I",#1,"WGL": GOTO 1360
1350 OPEN "I",#1,"YAKUTAT": GOTO 1360
1360 IF EOF(1) THEN 2240
1370 LINE INPUT#1,L$
1380 N$=MID$(L$,1,17)
1390 M$=MID$(L$,19,4)
1400 LA$=MID$(L$,23,6)
1410 LO$=MID$(L$,29,7)
1420 VC$=MID$(L$,36,3)
1430 VC=VAL(VC$)
1440 LU$=MID$(L$,39,1)
1450 LU=VAL(LU$)
1460 AN$=MID$(L$,40,22)
1470 P$=MID$(L$,64,1)
1480 P=VAL(P$)
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```
1490 K$=MID$(L$,65,1)
1500 K=VAL(K$)
1510 S$=MID$(L$,66,1)
1520 S=VAL(S$)
1530 R$=MID$(L$,67,1)
1540 R=VAL(R$)
1550 H$=MID$(L$,68,1)
1560 H=VAL(H$)
1570 C$=MID$(L$,69,1)
1580 C=VAL(C$)
1590 CT$=MID$(L$,70,1)
1600 CT=VAL(CT$)
1610 KO$=MID$(L$,71,1)
1620 KO=VAL(KO$)
1630 RT$=MID$(L$,72,1)
1640 RT=VAL(RT$)
1650 SH$=MID$(L$,73,1)
1660 SH=VAL(SH$)
1670 DV$=MID$(L$,74,1)
1680 DV=VAL(DV$)
1690 BT$=MID$(L$,75,1)
1700 BT=VAL(BT$)
1710 GR$=MID$(L$,76,1)
1720 GR=VAL(GR$)
1730 CA$=MID$(L$,82,1)
1740 CA=VAL(CA$)
1750 IF E$=MID$(N$,1,LE) THEN 1780
1760 IF Q>0 THEN PRINT "THERE ARE NO MORE MATCHING RECORDS.": GOTO 2260
1770 GOTO 1360
1780 LET Q=Q+1
1790 PRINT
1800 PRINT "THE NAME IS " TAB(35) N$
1810 IF P=1 THEN PRINT "WATER TYPE:" TAB(35) "LAKE"
1820 IF P=2 THEN PRINT "WATER TYPE:" TAB(35) "STREAM"
1830 IF P=3 THEN PRINT "WATER TYPE:" TAB(35) "GENERAL LOCATION
```

```
1840 PRINT
1850 PRINT "THE USGS MAP REFERENCE IS:" TAB(35) M$
1860 PRINT "THE LATITUDE IS:" TAB(35) LA$;" N"
1870 PRINT "THE LONGITUDE IS:" TAB(35) LO$;" W"
1880 IF LEFT$(AN$,1)="1" THEN GOTO 1910
1890 PRINT "THIS WATER IS NOT ACCESSIBLE TO ANADROMOUS FISHES."
1900 GOTO 1930
1910 PRINT "THIS WATER IS ACCESSIBLE TO ANADROMOUS FISHES."
1920 PRINT "THE ANADROMOUS STREAM/LAKE NO. IS:";AN$
1930 PRINT "THE FOLLOWING SPECIES OCCUR IN THIS WATER:"
1940 PRINT
1950 IF K=1 THEN PRINT TAB(35) "CHINOOK SALMON"
1960 IF S=1 THEN PRINT TAB(35) "COHO SALMON"
1970 IF R=1 THEN PRINT TAB(35) "SOCKEYE SALMON"
1980 IF H=1 THEN PRINT TAB(35) "PINK SALMON"
1990 IF C=1 THEN PRINT TAB(35) "CHUM SALMON"
2000 IF CT=1 THEN PRINT TAB(35) "CUTTHROAT TROUT"
2010 IF KO=1 THEN PRINT TAB(35) "KOKANEE"
2020 IF DV=1 THEN PRINT TAB(35) "DOLLY VARDEN"
2030 IF SH=1 THEN PRINT TAB(35) "STEELHEAD TROUT"
2040 IF RT=1 THEN PRINT TAB(35) "RAINBOW TROUT"
2050 IF BT=1 THEN PRINT TAB(35) "BROOK TROUT"
2060 IF GR=1 THEN PRINT TAB(35) "GRAYLING"
2070 PRINT
2080 IF LU>4 THEN GOTO 2100
2090 IF LU<5 THEN PRINT "THIS WATER IS LOCATED IN THE TONGASS NATIONAL FOREST."
2100 IF LU=6 THEN PRINT "THIS WATER IS LOCATED ON CITY OR STATE OWNED LAND."
2110 IF LU=7 THEN PRINT "THIS WATER IS LOCATED ON PRIVATELY OWNED LAND."
2120 IF LU=8 THEN PRINT "THIS WATER IS ON NATIONAL PARK LAND."
2130 IF CA>0 THEN PRINT "THERE IS/ARE";CA;"RECREATIONAL CABIN(S) PRESENT."
2140 PRINT
2150 IF LU>4 THEN GOTO 2170
2160 GOSUB 3790
2170 PRINT "HIT THE SPACE BAR TO CONTINUE THE SEARCH, OR THE CARRIAGE"
2180 PRINT "RETURN TO END THE PROGRAM."
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```
2190 K$=INKEY$: IF K$="" THEN GOTO 2190
2200 IF ASC(K$)=32 GOTO 1360
2210 IF ASC(K$)=13 GOTO 3610 ELSE GOTO 2190
2220 STOP
2230 GOTO 1360
2240 IF Q=0 THEN PRINT "THIS WATER IS NOT IN THE FILE."
2250 PRINT "MAKE SURE YOU ARE SEARCHING THE CORRECT AREA FILE."
2260 PRINT "DO YOU WANT TO KNOW SOMETHING ABOUT ANOTHER LAKE OR STREAM? (Y/N)"
2270 LET Q=0
2280 PRINT
2290 K$=INKEY$: IF K$="" GOTO 2290
2300 IF ASC(K$)=89 OR ASC(K$)=121 THEN GOTO 2320
2310 IF ASC(K$)=78 OR ASC(K$)=110 THEN GOTO 3610 ELSE GOTO 2290
2320 CLOSE
2330 CLS:LOCATE 12,15
2340 PRINT "ENTER THE NAME OF THE LAKE OR STREAM."
2350 GOTO 950
2360 PRINT
2370 PRINT
2380 CLS:LOCATE 10,1
2390 PRINT "          TO GET A LIST OF WATERS THAT CONTAIN A SPECIFIED SPECIES,
2400 PRINT "                ENTER THE APPROPRIATE SPECIES CODE:"
2410 PRINT
2420 PRINT "          CHINOOK SALMON=1; COHO SALMON=2; SOCKEYE SALMON=3"
2430 PRINT "          PINK SALMON=4;  CHUM SALMON=5;  CUTTHROAT TROUT=6"
2440 PRINT "          KOKANEE=7;   RAINBOW TROUT=8;   STEELHEAD TROUT=9"
2450 PRINT "          DOLLY VARDEN=10;   BROOK TROUT=11;    GRAYLING=12"
2460 LOCATE 18,34:INPUT A
2480 IF A>0 AND A<13 THEN GOTO 2500 ELSE GOTO 2490
2490 PRINT "TRY AGAIN, PLEASE": GOTO 2460
2500 CLS:PRINT TAB(19) "WHICH AREA DO YOU WANT TO SEARCH?"
2510 PRINT
2520 PRINT
2530 PRINT
```

```
2540 PRINT TAB(18) "ALL OF SOUTHEAST ALASKA- - - - - 1"
2550 PRINT TAB(18) "ADMIRALTY ISLAND- - - - - - - - -  2"
2560 PRINT TAB(18) "BARANOF ISLAND AREA - - - - - - -  3"
2570 PRINT TAB(18) "CHICHAGOF ISLAND AREA - - - - - -  4"
2580 PRINT TAB(18) "JUNEAU MAINLAND AREA - - - - - - - 5"
2590 PRINT TAB(18) "HAINES/SKAGWAY AREA - - - - - - -  6"
2600 PRINT TAB(18) "KETCHIKAN AREA - - - - - - - - - - 7"
2610 PRINT TAB(18) "PETERSBURG AREA - - - - - - - - -  8"
2620 PRINT TAB(18) "PRINCE OF WALES ISLAND AREA - -  9"
2630 PRINT TAB(18) "STEPHENS PASSAGE MAINLAND AREA- 10"
2640 PRINT TAB(18) "WRANGELL AREA - - - - - - - - - - 11"
2650 PRINT TAB(18) "YAKUTAT AREA - - - - - - - - - -  12"
2660 PRINT:PRINT:PRINT:PRINT:PRINT
2670 INPUT "               ENTER THE APPROPRIATE AREA CODE:";B
2675 CLS
2680 ON B GOTO 2690,2700,2710,2720,2730,2740,2750,2760,2770,2780,2790,2800
2690 OPEN "I",#1,"ALANA.PRN": GOTO 2810
2700 OPEN "I",#1,"ADMIRALT": GOTO 2810
2710 OPEN "I",#1,"BARANOF": GOTO 2810
2720 OPEN "I",#1,"CHICH": GOTO 2810
2730 OPEN "I",#1,"JUNEAU": GOTO 2810
2740 OPEN "I",#1,"HNSSK": GOTO 2810
2750 OPEN "I",#1,"KETCH": GOTO 2810
2760 OPEN "I",#1,"PSG": GOTO 2810
2770 OPEN "I",#1,"POW": GOTO 2810
2780 OPEN "I",#1,"STEPHPAS": GOTO 2810
2790 OPEN "I",#1,"WGL": GOTO 2810
2800 OPEN "I",#1,"YAKUTAT": GOTO 2810
2810 LET DD$=""
2820 PRINT "------------------------------------------------------------------------
-----"
2830 PRINT "NAME OR LOCATION" TAB(29) "TYPE" TAB(43) "MAP REF." TAB(57) "STREAM
NUMBER"
2840 PRINT "------------------------------------------------------------------------
-----"
```

```
2850 PRINT
2860 IF EOF(1) THEN GOTO 3500
2870 LINE INPUT#1,L$
2880 N$=MID$(L$,1,17)
2890 M$=MID$(L$,19,4)
2900 LA$=MID$(L$,23,6)
2910 LO$=MID$(L$,29,7)
2920 VC$=MID$(L$,36,3)
2930 VC=VAL(VC$)
2940 LU$=MID$(L$,39,1)
2950 LU=VAL(LU$)
2960 AN$=MID$(L$,40,22)
2970 P$=MID$(L$,64,1)
2980 P=VAL(P$)
2990 K$=MID$(L$,65,1)
3000 K=VAL(K$)
3010 S$=MID$(L$,66,1)
3020 S=VAL(S$)
3030 R$=MID$(L$,67,1)
3040 R=VAL(R$)
3050 H$=MID$(L$,68,1)
3060 H=VAL(H$)
3070 C$=MID$(L$,69,1)
3080 C=VAL(C$)
3090 CT$=MID$(L$,70,1)
3100 CT=VAL(CT$)
3110 KO$=MID$(L$,71,1)
3120 KO=VAL(KO$)
3130 RT$=MID$(L$,72,1)
3140 RT=VAL(RT$)
3150 SH$=MID$(L$,73,1)
3160 SH=VAL(SH$)
3170 DV$=MID$(L$,74,1)
3180 DV=VAL(DV$)
3190 BT$=MID$(L$,75,1)
```

```
3200 BT=VAL(BT$)
3210 GR$=MID$(L$,76,1)
3220 GR=VAL(GR$)
3230 IF LA$=DD$ THEN GOTO 2860
3240 LET DD$=LA$
3250 ON A GOTO 3260,3280,3300,3320,3340,3360,3380,3400,3420,3440,3460,3480
3260 IF K=1 THEN GOSUB 3700
3270 GOTO 2860
3280 IF S=1 THEN GOSUB 3700
3290 GOTO 2860
3300 IF R=1 THEN GOSUB 3700
3310 GOTO 2860
3320 IF H=1 THEN GOSUB 3700
3330 GOTO 2860
3340 IF C=1 THEN GOSUB 3700
3350 GOTO 2860
3360 IF CT=1 THEN GOSUB 3700
3370 GOTO 2860
3380 IF KO=1 THEN GOSUB 3700
3390 GOTO 2860
3400 IF RT=1 THEN GOSUB 3700
3410 GOTO 2860
3420 IF SH=1 THEN GOSUB 3700
3430 GOTO 2860
3440 IF DV=1 THEN GOSUB 3700
3450 GOTO 2860
3460 IF BT=1 THEN GOSUB 3700
3470 GOTO 2860
3480 IF GR=1 THEN GOSUB 3700
3490 GOTO 2860
3500 PRINT
3510 PRINT "--------------------------------------------------------------------
-------"
3520 PRINT
```

```
3530 PRINT TAB(14) "DO YOU WANT TO SORT FOR ANOTHER SPECIES? (Y/N)"
3540 PRINT
3550 PRINT
3560 PRINT
3570 K$=INKEY$: IF K$="" GOTO 3570
3580 IF ASC(K$)=89 OR ASC(K$)=121 THEN GOTO 3600
3590 IF ASC(K$)=78 OR ASC(K$)=110 THEN GOTO 3610 ELSE GOTO 3570
3600 CLOSE: GOTO 2380
3610 CLOSE
3620 PRINT TAB(14) "IF YOU WANT TO DO MORE SEARCHING, TYPE (Y)."
3630 PRINT TAB(14) "IF YOU NEED INSTRUCTIONS AGAIN, TYPE (I)."
3640 PRINT TAB(14) "IF YOU WANT TO EXIT THE PROGRAM TYPE (E)."
3650 K$=INKEY$: IF K$="" GOTO 3650
3660 IF ASC(K$)=89 OR ASC(K$)=121 THEN GOTO 820
3670 IF ASC(K$)=73 OR ASC(K$)=105 THEN GOTO 200
3680 IF ASC(K$)=69 OR ASC(K$)=101 THEN GOTO 3770 ELSE GOTO 3650
3690 END
3700 LET PP$="LAKE"
3710 LET PX$="STREAM"
3720 LET PT$="STREAM(LOC)"
3730 IF P=1 THEN PRINT N$,PP$,M$,AN$
3740 IF P=2 THEN PRINT N$,PX$,M$,AN$
3750 IF P=3 THEN PRINT N$,PT$,M$,AN$
3760 RETURN
3770 CLS
3780 RUN "MENU"
3790 OPEN "R",#2,"VCURDM.DTA",10
3800 FIELD #2, 3 AS VCU$, 1 AS LUD$, 1 AS SF$, 1 AS FG$, 1 AS UW$, 1 AS QW$, 1 A
S VW$, 1 AS SW$
3810 LET V=VC
3820 GET #2,V
3830 PRINT "VCU" TAB(15) "LUD" TAB(25) "SPORT FISH RANK" TAB(45) "FHIP CLASS"
3840 PRINT "___" TAB(15) "___" TAB(25) "_______________" TAB(45) "__________"
3850 PRINT VCU$, TAB(16) LU$, TAB(32) SF$ TAB(50) FG$
3860 PRINT:PRINT
3870 CLOSE #2
3880 RETURN 2170
```

APPENDIX B.

706(b) FISHERIES DRAFT
EFFECTS OF LOGGING ON FISH

INTRODUCTION

Land and water system processes that shape the character of the aquatic environment are complex and dynamic. The activities of man can affect these processes in ways that result in environmental changes that go beyond natural effects or result in impacts that otherwise would not have taken place.

Salmonid fishes have definite freshwater habitat requirements. Considerable data have been collected that indicate timber harvesting and associated road construction activities alter many habitat variables critical to salmonid fishes. Certain of these impacts singularly or collectively produce short and long term effects on salmonid populations and their users. However, in Alaska, long term effects of logging on fish populations are still not completely understood because logging and related research are relatively new to the region.

IMPORTANT ENVIRONMENTAL VARIABLES - AQUATIC HABITAT

STREAMFLOW

Streamflow is defined as "the amount of water flowing in a channel per unit time", and is only meaningful in regards to fish habitat when it is correlated with water velocity, depth, the amount of channel covered, and how the flow, at a particular time, compares to what is considered normal for the channel (Chamberlain, 1982).
Streamflow can be a barrier to fish movement when the depth is too shallow or velocity is too high (Thompson, 1972). Obviously, when there is no escape from depths too shallow to maintain adequate oxygen and moisture for a fish, death results.

There will be optimum streamflows for given channels that will maximize availability of spawning area. If flows are so low that suitable spawning gravel is dewatered, this is undesirable. As flow increases, there is a level past which velocity may be so fast as to wash away eggs that have been deposited in the gravel.

Streamflow requirements of incubating salmonid eggs are mostly unknown because it is difficult to determine what is happening in the intragravel environment based on surface flows. However, it is assumed that to assure adequate incubation of salmonid embryos, there should be enough surface flow to allow emergence of fry and velocities no greater than that which would scour gravel from redds ("nests" where eggs have been deposited).

Recommended streamflows for rearing salmonids have usually been based on relationships to habitat components like food or cover rather than directly to numbers or biomass of fish (Reiser and Bjornn, 1979). Density of juvenile anadromous salmonids may be regulated by the abundance of food in some streams (Chapman, 1966). Food comes primarily from the substrate of the stream and adjacent land, and is largely comprised of aquatic and terrestrial insects and other invertebrates.

Some researchers believe that water velocity is the most important parameter in determining the distribution of aquatic invertebrates in streams (Scott, 1958; Allen, 1959). The relationship between water depth and aquatic invertebrate production is not well understood. In one study, mayflies, stoneflies, and caddisflies were found in depths less than 0.3 meters (Kimble and Wesche, 1975). Hooper (1973) reported that areas of highest invertebrate production most often occurs in streams at depths between 0.15 and 0.9 meters if substrates and velocities are suitable.

Requirements for space by juvenile salmonids in streams vary with species, age, and time of year and are likely related to abundance of food (Chapman, 1966). Standing crop of coho salmon has been shown to be directly related to pool volume (Nickelson and Hafele, 1978) and a similar relationship has been shown for chinook salmon in small streams (Bjornn et al., 1977).

Streamflow is but one aspect or process of the hydrologic cycle of a watershed. It can be considered the output in the overall water balance equation:

$$\text{Inputs} - \text{Losses} \pm \text{storage} = \text{Output},$$

where inputs include rain, snow, and fog drip; losses include evaporation from water, ground, and foliage, transpiration from plants, and deep seepage to ground-water tables; storage may be in surface depressions, the soil, in channels, or as snowpacks; and, as mentioned above, stream runoff is the output. The above equation deals only with amounts of water and not with rates of movement.

Timber harvesting usually does not alter the total amount of rain or snow falling on a watershed basin (Troendle, 1980). There is one exception, where foliage intercepts significant quantities of fog (Harr, 1980), which may be lost after timber harvesting. This has not been shown to be an important part of the water cycle in Southeast Alaska.

Timber harvesting may, however, dramatically change the distribution of water and snow on the ground, the amount intercepted or evaporated by foliage, the rate of snow melt or evaporation from snow, the amount that can be stored in the soil or transpired from the soil by vegetation, and the physical structure of the soil, which determines the rate and routes of water movement to stream channels (Chamberlain, 1982).

There is now ample documentation that stream flow generally increases after clearcut logging (Rowe, 1963; Rothacher, 1965, 1970, 1971; Berndt and Swank, 1970; Meehan et al., 1969). Streams of low discharge are affected more than larger streams (Riggs, 1965).

Clear cut areas alter wind patterns, resulting in more snow being trapped in them. Winds can often be more intense in forest openings, which will also augment snow melt. Because the soil in forest openings is wetter and nearer its saturation level, melt water comes out faster, which can result in earlier and higher peak flows (Swanson and Hillman, 1977; Gary, 1979; Troendle, 1980). Whether or not increased flows from a logged area actually cause a change in the runoff for an entire basin depends on the distribution of openings in the basin, their aspect, elevation, and distance from stream channels.

Removal of trees from a forest area eliminates countless leaves and stems that would have intercepted, stored, and reevaporated rain and snow. The death of tree roots also reduces the amount of water that can be transpired from the soil and removed from runoff. Increases in ground-water levels and content of water in soils also weakens soil strength and leads to increased rates of slope mass movements after timber harvesting (O'Loughlin, 1972; Swanston, 1974). Finally, it has been shown that road construction has an effect on peak streamflows (Gilleran, 1968; Harper, 1969; Hsieh, 1970; Harr et al., 1975).

WATER QUALITY

The principal water quality parameters of salmonid fish habitat that may be affected by timber harvest activities are temperature, dissolved oxygen, sediment, and nutrients (Chamberlain, 1982).

Temperature: Salmonid fishes are cold water organisms, and have definite thermal requirements. Water temperature affects growth rate, swimming ability, functional behaviors like catching and using food, and resistance to disease. Temperature also affects availability of dissolved oxygen in water. The following table lists preferred, optimum, and upper lethal temperatures (degrees Celsius) of selected Salmonid fishes:

SPECIES	PREFERRED TEMP. RANGE	OPTIMUM TEMP.	UPPER LETHAL
Chinook	7.3 - 14.6	12.2	25.2
Coho	11.8 - 14.6	---	25.8
Chum	11.2 - 14.6	13.5	25.8
Pink	5.6 - 14.6	10.1	25.8
Sockeye	11.2 - 14.6	---	24.6
Steelhead	7.3 - 14.6	10.1	24.1
Cutthroat	9.5 - 12.9	---	23.0

(Reiser and Bjornn, 1979)

As the data in the above table show, salmonids generally prefer rather narrow ranges of temperature. Laboratory experiments indicate temperature can regulate the density of rearing salmonids (Hahn, 1977).

There are upper and lower thermal limits for successful incubation of salmonid eggs. Combs and Burrows (1957) and Combs (1965) showed that pink and chinook salmon eggs can tolerate long periods of low temperature as long as the temperature during initial deposition and early embryogenesis is above 6.0° C. Extremely cold air and water can cause mortality on incubating eggs and alevins (yolk sac fry) by the formation of frazil ice or anchor ice that reduce water exchange in the gravel (Neave, 1953; McNeil, 1966; Reiser and Bjornn, 1979).

Temperature of water can affect upstream migration of adult anadromous salmonids (Reiser and Bjornn, 1979). Abnormal stream temperatures can facilitate disease outbreaks and accelerate or retard ripening for spawning. There is an inverse relationship between temperature of water and how much dissolved oxygen the water can contain. As water warms, its capacity for containing dissolved oxygen is diminished, which in turn can lead to hypoxia in salmonids. Dissolved oxygen will be discussed in more detail later.

The removal of streamside vegetation during timber harvest activities increases solar radiation to the stream and results in warmer water during the summer, especially in small streams (Greene, 1950; Chapman, 1962; Reinhart et al., 1963; Brown and Krygier, 1967, 1970; Levno and Rothacher, 1967; Gray and Edington, 1969; Meehan et al., 1969; Meehan, 1970; Brown et al., 1971; Narver, 1972; Tyler and Gibbons, 1973; Moring and Lantz, 1974). The magnitude of temperature change depends on the amount of timber harvested adjacent to a stream (Meehan et al., 1969; Brown and Krygier, 1970).

One of the most detailed studies on the effects of logging on a watershed has been the 15 year Alsea Watershed Study in coastal Oregon (Moring, 1975). Three small headwater tributaries were studied. One stream served as a control and remained unlogged, another watershed was completely clearcut, and a third was partially clearcut with buffer strips left along the stream. Water temperature ranges and maximums increased in the completely cut watershed and monthly average temperatures increased over pre-logging averages by 12.7° C in June, 11.8° C in July, and 9.3° C in August. Water temperatures in the completely cut watershed exceeded the pre-logging maximum fluctuation (4.4° C) 28% of the days in 1966 and 82% of the days in 1967.

Removal of riparian vegetation in northern areas may result in lower stream temperatures during winter, increasing the chances for frazil and anchor ice formation (Chamberlain, 1982).

Dissolved Oxygen: There exists a range of concentrations of dissolved oxygen critical to the survival and development of salmonid eggs and embryos (Lindroth, 1942; Hayes et al., 1951; Wickett, 1954; Alderdice et al., 1958). Laboratory tests with coho, chum, and chinook salmon, and steelhead eggs indicate the following relationships: sac fry from embryos incubated in low and intermediate oxygen concentrations are smaller and weaker than sac fry reared at higher concentrations (Silver et al., 1963); reduced oxygen concentrations lead to smaller newly hatched fry and a lengthened incubation period (Shumway et al., 1964); and low oxygen concentrations in the early stages of development may delay hatching or increase the incidence of abnormal embryos (Alderdice et al., 1958).

The concentration of dissolved oxygen in streams is important to rearing salmonids. Generally, stream water is at or near saturation levels for oxygen, however, as mentioned earlier, the warmer the water, the less dissolved oxygen the water can contain at saturation. Herrmann et al. (1962) showed that growth rate, food consumption rate, and the efficiency of food utilization of juvenile coho salmon all decline when oxygen is less than 6 mg/L. Also, juvenile chinook salmon avoid water with oxygen concentrations near 1.5 to 4.5 mg/L in the summer, but react less to low levels in the fall when temperatures are lower (Whitmore et al., 1960). Swimming speed of rainbow trout is impaired by reduced oxygen levels in the water (Jones, 1971).

Reduced dissolved oxygen concentrations can adversely affect the swimming performance of migrating salmonids (Reiser and Bjornn, 1979). Low dissolved oxygen can also cause avoidance reactions or cause migration to stop (Whitmore et al., 1960). Oxygen levels recommended for spawning fish include levels at the 80% saturation level and temporary absolute levels no lower than 5.0 mg/L.

Concentrations of dissolved oxygen may be reduced in the intergravel spaces if fine organic debris accumulates on and in stream beds, which places a higher biological oxygen demand on available supplies. Research has also shown that excessive logging debris in streams can reduce stream velocity and exchange of intergravel water. Sometimes the clogging of surface gravels by fine sediments can also restrict intergravel flow enough to lower dissolved oxygen concentrations, but this is more often associated with road construction and land slides (Chamberlain, 1982).

The Alsea Watershed Study looked at the effects of logging on dissolved oxygen. The tributary (Needle Branch) in the watershed, completely clearcut, with no buffer strips, showed sharp declines in surface dissolved oxygen levels during the summer of logging, when debris was in the stream bed. After debris was removed and winter rains came, surface levels of dissolved oxygen returned to pre-logging levels (Moring, 1975). The study also showed there to be a dramatic decrease in intragravel dissolved oxygen during the winter after logging.

Sediment Load: Suspended and deposited fine sediment can adversely affect salmonid habitat if present in excessive amounts. Streams with silt loads averaging less than 25 mg/L can be expected to support good freshwater fisheries (Reiser and Bjornn, 1979). This assumes other environmental elements to be suitable. High levels of suspended solids may abrade and clog fish gills, reduce feeding, and cause fish to avoid some areas (Trautman, 1933; Pautzke, 1938; Smith, 1939; Kemp, 1949; Wallen, 1951; Cooper, 1956; Bachman, 1958; Cordone and Kelley, 1961). McNeil and Ahnell (1964) determined that highly productive spawning streams have gravels with high permeability. Permeability is high when bottom materials have less than 5% sands and silts and is low when fine sediments make up more than 15% of the bottom material.

Successful fry emergence is impaired by excessive amounts of sand and silt in the gravel. Koski (1966) examined redds where eggs had developed normally but the hatched fry were unable to emerge because of sediment. Phillips et al. (1975) found an inverse relation between quantity of fine sediments and fry emergence.

Suspended sediment directly affects rearing salmonids. Long term exposure of coho salmon and steelhead to suspended sediment (11-14 days at 23-84 NTU's) results in lower growth rates and greater emigration from test channels (Sigler et al., 1984). Observations of trout in the wild indicate that fish cease feeding at 35 mg/L suspended sediment (Bachman, 1958) or reduce their feeding rate (Bachman, 1984). Decrease in feeding rates may be responsible for low growth rates of salmonids, as observed by Sigler et al. (1984). Suspended sediment can fill in the interstices of, or completely cover, stream gravels, and where gravels are used as cover by juveniles, suitable foraging sites and refuge sites may be lost. This has been shown to reduce the rate of production in coho (Crouse et al., 1981) or cause emigration of steelhead and chinook (Bjornn et al., 1977).

Suspended sediment in streams is increased from accelerated surface erosion or slope mass movements, both of which may result from timber harvest and road construction activities. The Alsea Study showed there was an increase in suspended sediments from 293.8 to 451.0 metric tons per year in Deer Creek (the watershed with patchy clearcuts and buffer strips) following road construction. There was an increase from 39.5 to 120.6 metric tons per year (205.0% increase) in suspended sediments in Needle Branch (the watershed completely clearcut). These are significant changes (95% confidence level). Sediment discharge increased by only 0.1% in Flynn Creek (control creek) during the same time period.

<u>Nutrient Cycling</u>: There is very limited information regarding nutrient cycling in aquatic habitats and even less pertaining to the relationships of nutrient cycling to fish production.

There is evidence that there can be dramatic increases in levels of nitrate, phosphate, and organic carbon in streams after nearby logging and slash burning, however, there is no evidence that this has a deleterious effect on fish. If nutrient enrichment results in algal blooms, algae could clog interstitial space in gravel, which could be detrimental to fish production (Chamberlain, 1982).

PHYSICAL HABITAT FEATURES

Stream banks: Stream bank areas provide lower water velocities compared to main stream currents. Undercut banks, overhanging root complexes, vegetation, and stable debris provide shade and protection from predators. Root networks contribute to stream bank stability and minimize bank erosion during high water flows (Chamberlain, 1982).

Stream banks, more than any other habitat component, are susceptible to direct effects from logging activity. Felling trees across streams, yarding trees through or across streams, operating heavy machinery adjacent to streams, and removing vegetation which has roots that strengthen stream bank soil structure, all can potentially drastically affect the integrity of stream banks. Water table increases in riparian zones also weaken stream bank structure (Chamberlain, 1982).

Riparian Vegetation: Plants living adjacent to streams, as mentioned above, help maintain stream bank integrity, which in turn provides continued shelter for rearing and spawning anadromous salmonids. Riparian vegetation also directly provides overhead cover and protection for fish. Certain anadromous salmonids, like chinook salmon and steelhead trout enter freshwater months before they spawn, and cover is essential for fish waiting to spawn (Reiser and Bjornn, 1979). Nearness of cover to spawning areas may be a factor in the selection of spawning sites by some species (Johnson et al., 1966; Reiser and Wesche, 1977).

Cover is extremely important to rearing salmonids, because this is when they are very vulnerable to predation by other fish, birds and mammals. Overhead cover, as provided by riparian vegetation, is used by most salmonids (Newman, 1956; Wickham, 1967; Butler and Hawthorne, 1968; Baldes and Vincent, 1969; Bjornn, 1969; Chapman and Bjornn, 1969; Lewis, 1969).

Not only does streamside vegetation provide cover and maintain stream bank integrity and stability, it also provides shade which is important in maintaining cool water, as discussed earlier. This appears to be important not just in temperate zones but in Southeast Alaska as well (Meehan, 1970).

Plant detritus (dead matter) that falls into streams from streamside vegetation may be an important source of food to aquatic invertebrates, which in turn are sources of food for fish. Terrestrial insects and other invertebrates that fall into streams from nearby plants also are eaten by fish. Sekulich and Bjornn (1977) found that terrestrial insects are second only to chironomids (midge fly larvae) in importance as food for juvenile anadromous salmonids in the streams they studied. In Southeast Alaska, rearing anadromous salmonids feed heavily on invertebrates that either fall from riparian vegetation, or else live in the streams but obtain energy from riparian plant detritus (Schmidt and Robards, 1974; Schmidt, 1975; Schmidt, 1976).

Finally, large plants like spruce, hemlock, and cottonwood provide sources of large organic debris (LOD) when they fall into streams after death, when wind blows trees over, or when currents cut banks and undermine these large trees. These downed trees, which have a stream life yet to be accurately determined, create water velocity barriers, plunge pools, and provide cover for rearing and spawning anadromous salmonids. LOD appears to have a significant role in the evolution and maintenance of stream habitat diversity.

Barriers: Permanent blocks to fish movements, like large waterfalls, have always been a significant factor in shaping the distribution of anadromous salmonids in a stream system. Man has often attempted to open up new habitat for anadromous fish by devising ways to get fish above insurmountable waterfalls. Other natural barriers to upstream migrants may include excessive water velocities, debris jams, low water flows, excessive water temperatures, and pollution. All of these are of a more temporary nature, with the possible exception of large debris jams, and all can also be the result of the activities of man.

Debris jams, whether natural or caused by human activities, can prevent or delay upstream migration. One study showed there was a 75% decrease in spawning salmon in a stream because of debris blockage (Chapman, 1962). Elliott (in press) also found that removal of logging debris improved access to adult pink salmon and provided new spawning habitat. However, it is important to remember that large organic debris (LOD) is an important habitat feature and is beneficial to fish. All debris jams should be evaluated before they are removed (Reiser and Bjornn, 1979; Bryant, 1983).

With the exception of debris jams, the creation or elimination of migration barriers is more often associated with engineering projects accompanying timber harvest rather than the cutting and yarding of trees (Chamberlain, 1982).

One of the greatest hazards associated with logging to anadromous salmonids is the improper placement of culverts where logging roads cross streams. Road culverts can restrict upstream access for fish by creating outfall barriers (waterfalls), having excessive water velocity in the culvert, not having sufficient water in the culvert, lacking resting pools below the culvert, or having any combination of the above conditions (Yee and Roelofs, 1980). In addition to improper culvert placement, hillside logging debris can, over time, collect at the heads of culverts, causing fish blocks (Chamberlain, 1982).

SHORT TERM EFFECTS ON FISH

CHANGES IN WATER QUALITY

TEMPERATURE

The effects of clearcutting on stream temperature is well documented; temperature increases with the amount of stream exposed to sunlight. In Southeast Alaska, Meehan et al. (1969) found that temperature increased after logging of the Harris and Maybeso Rivers, but that temperatures did not reach levels lethal to juvenile salmonids. Rearing salmonids are cold water adapted fish and even sub-lethal temperatures can affect their growth and behavior. Salmonids cease growth at 20.3° C because of increased metabolic activity at higher temperatures This is because energy from food is used to drive high metabolic rates and little remains for growth. Growth rates of chinook parr increase as temperature increases from 10.0° C to 15.7° C; growth rates then decrease with increasing temperature (Burrows in Reiser and Bjornn, 1979). A similar relation for brook trout has been shown. Growth rate increases as temperature increases from 9.1° to 13.1° C and there is a decrease in growth rate after temperature exceeds 17.1° C. At 17.1° C, brook trout cease feeding and at 21.2° C eat only 0.85% of their body weight per day (Baldwin, 1956).

Temperature may also regulate the density of salmonids. Hahn (1977) found twice as many steelhead fry in stream channels at 13.5° C than in a channel at 18.5° C and that fry density at 8.5° C was double that at 13.5° C. Stream temperatures in Southeast Alaska frequently exceed these levels during the months of July and August. Meehan et al. (1969) observed that maximum temperatures in logged streams exceed those of unlogged control streams by about 5° C. Thus, it can be concluded that, in streams that have been logged, there will be extended periods of high temperature which may affect feeding, growth rate, and the density of juvenile salmonids more than would occur in forested streams.

High summer air temperature has been associated with adult salmon mortality. The Alaska Department of Fish and Game compiled a list of 43 streams that had mortality of pink and chum salmon in 1977 associated with high water temperature and low flow. The largest clear cut in Alaska is located within the watershed of Staney Creek. In 1979, 15,000 pink salmon died there before spawning, a result of warm water and low oxygen. In an effort to help cool Staney Creek, the USFS planted cottonwood trees along the stream to provide shade. Murphy (in press) has shown that mortality of adult salmon was, in one instance, primarily due to low water rather than warm water. Fish got stranded in pools when the water level became low and then they depleted the oxygen in the water. High temperature can exacerbate the problem because warmer water contains less oxygen at saturation. Still, Murphy's account documents a situation where suffocation was the cause of mortality, rather than thermal shock.

Hartman et al. (1982) discovered that winter water temperatures were higher after logging of Carnation Creek, although they concluded that water temperatures were primarily dependent on air temperatures and general local climate. However, they speculated that, after logging, more soil is exposed to solar radiation and the watershed may act as a heat sink to capture and store heat. This stored heat is transferred to ground water and to streams.

Increased winter stream temperatures appear to have accelerated the rate of development of coho salmon embryos in the gravel, for they emerged up to six weeks earlier than normal after logging. Early emergence, however, occurred at a time when floods were common and many fry were swept out to sea, raising the concern that under-utilization of habitat could result (Scrivener and Andersen, 1984). Those fish that escaped floods experienced a longer growing season and were larger by the end of the first year. It is presumed that temperature regimes return to normal levels after regrowth of vegetation occurs in the watershed.

Sediment Loads

Clear cutting practices, construction of logging roads, and resultant land slides have caused sediment to wash into salmon streams (Sheridan and McNeil, 1968; Novak, 1975; Cordone and Kelly, 1961). Studies conducted in Southeast Alaska on the effects of sedimentation on salmon, have focused on sediment particles with diameters of 0.833 mm or smaller as those most likely reducing gravel permeability. A significant percentage increase in this size range of sediment was noted in the Harris River by Sheridan and McNeil (1968) and in 108 Creek by Novak (1975) following logging. However, results from these early studies were inconclusive regarding effects on salmon numbers because of the variation in escapement management (Pella and Myren, 1974; Sheridan, 1982).

Sheridan (1982) recommends assessment of numbers of spawners, egg deposition, number of pre-emergent fry, sediment levels in the gravels in selected portions of the stream, and evaluation of the effects of climatic variability on embryo survival to assess the impact of logging. The early methods of sampling gravel for sediment composition, measured maximum percentages of particles less than 0.833 mm diameter, at about 19.0 percent by volumetric analysis (Sheridan, 1982) and 13.0 percent by gravimetric analysis for old growth forest conditions (Edgington, 1982).

Current methods of sampling gravel use the single or triple freeze core technique (Everest et al., 1981) which were developed to reduce sample size variation. The Forestry Science Laboratory in Juneau has studies in progress designed to measure seasonal changes in gravel substrate of pink salmon spawning streams and to further understand the relationship of fine sediment and emergence of fry. Also in the final stages of testing by the laboratory is an instrument that will be able to measure intergravel water flow. This will greatly enhance efficiency of the study of survival of fry in the gravel by providing measurements of the most important single physical parameter of the gravel environment

(Meehan, 1984). The understanding of stream sedimentation dynamics in salmon streams is increasing, but is not at a level to address "trade-off" discussions in fish - forest management. Stringent guidelines governing logging practices are needed to minimize addition of sediments into streams (Sheridan et al., 1982).

Cederholm et al. (1981) showed that cumulative sedimentation from logging roads significantly reduces the survival of coho salmon eggs and alevins (sac fry in the gravel) (Clearwater, Washington). Where egg survival is being impaired both Cederholm (1981) and McNeil (1980) recommend increased escapement to off set the affect of lowered production. Contemporary data from the Carnation Creek study (Vancouver Is., B.C.) showed that a significant reduction in the survival of chum and coho from egg to emergent fry occurred due to fines settling in the top strata of gravel spawning beds after logging commenced (Scrivener and Brownlee, 1981). The Carnation Creek study also showed results that indicated that fines will shift out of gravels by large freshet flows when the source of sediment was arrested, however, fines less than 0.297 mm did persist in the gravel for more than a year.

Impacts of sedimentation on the survival of pink salmon, other than directly related to logging, are documented in the literature for Southeast Alaska. Benda (1983) showed that during road construction there was an 11.5% increase in sediment particles less than 4.0 mm diameter and a significantly lowered mean survival of pink salmon alevin resulting from a 2,300 m rock and overburden slide into a tributary of the Blossom River. Oftentimes, the rock source for a road is located above a stream on an adjacent mountain slope. In many cases fine powdered rock from the pit enters the stream via overland washing and becomes a chronic point-source of sedimentation (Edgington, 1976). Debris avalanches are natural events in the relative young soils of Southeast Alaska and the conditions that trigger such mass wasting are fairly well understood (Swanston, 1970). However, road building under mountain slopes and rainfall conditions conducive to avalanching caused two major land slides on Bear Creek (Mitkof Island) in 1976. These slides covered a total of 7 and 13 acres, dammed the stream and cost in excess of $29,000 to rehabilitate (Edgington, 1977). Bishop and Stevens (1964) noted an increase in the rate of landslides to more than four-fold in the Maybeso Creek valley after logging.

Occurences and extent of damage of landslides, or road building effects, is undocumented either by the State of Alaska or the USFS through a monitoring program. A reporting mechanism should be activated through the USFS to track sources and extent of land disturbances relating to salmon streams.

The USFS documented a logging contract violation that almost completely eliminated the odd year pink salmon cycle into Bayhead Creek, Freshwater Bay, in 1964. The Alaska Department of Fish and Game noted virtually no return of adults in 1965 and 1967 to Bayhead Creek, whereas, in 1966 and 1968 (the even year cycle) several thousand spawners returned to the creek. The logging violation, in this instance, was logging in and through the stream, creating massive siltation. A similar contract violation occurred in Saginaw Creek, Saginaw Bay, in 1965.

Most problems with sedimentation are caused by catastrophic incidents such as landslides or road failure caused by human error, poor layout design, or from activities in violation of standard practices. These events are preventable and uncommon, but unfortunately, sometimes still occur and are quite destructive.

Logging Slash and Debris Deposition

Clearcutting to or across small streams frequently deposits large quantities of woody debris, such as limbs, boles, and non-merchantable timber, in stream channels. Logging debris is generally smaller and accumulations more dense than naturally occurring debris. Bryant (1983) showed that, on Prince of Wales Island, logging can produce as much as seven times the amount of debris occurring in unlogged streams.

Hall and Baker (1975) summarized beneficial and adverse effects of organic debris on fish habitats. Most adverse effects arise from water quality impacts. Accumulations of debris increase biological oxygen demand (BOD) and heavy accumulations of fine organic material and decreases instream and intragravel oxygen (Hall and Lantz, 1969; Berry, 1974; Ponce, 1974). This material can also contribute toxic leachates (Buchanan et al., 1976). Water-soluble leachates of western red cedar (Thuga plicata) are toxic to juvenile coho salmon at 0.33 mg/L for foliage terpenes and 2.7 mg/L for tropolones (Peters et al., 1976). Neither BOD problems nor toxic concentrations from debris deposition have been documented in the field in Southeast Alaska.

Removal of logging residue from streams is a common practice and has been conducted on many streams in Southeast Alaska, but with virtually no evaluation of its effects on fish or other biota. Cardinal (1980) and Dolloff (1983) found that juvenile Dolly Varden and coho salmon are both highly associated with logging debris, and that densities in littered streams are similar to that of both species in pristine streams. Furthermore, Cardinal (1980) predicted that removal of logging debris would have a detrimental effect on abundance of rearing salmonids. Elliott (unpublished) found that removal of logging debris can cause an 80% reduction in the abundance of juvenile Dolly Varden, a temporary reduction in benthos numbers, and may cause a long-term destabilization of the char population. Bryant (1983) summarized these and other findings and developed concise guidelines for conditions under which debris is to be removed, goals of debris removal, and procedures for removal.

CHANGES IN THE PHYSICAL STRUCTURE OF THE HABITAT

Stream habitat provides two important functions that are directly related to the carrying capacity of stream salmonids; 1) habitat provides foraging sites where fish reside in low velocity "pockets" from which they venture out to perform various functions and 2) provides refuge habitat where they seek concealment when disturbed (Bachman, 1984). Habitat requirements change with age, size, and season (Bachman, 1982; 1984). Declining water temperatures during the fall reduce metabolic activity and swimming performance (Brett, 1964), and habitat may be selected that provides shelter for fish from floods (Bustard and Narver, 1975 a and b). Winter habitat may be the most critical factor in determining the annual abundance of juveniles during their freshwater life, for in the absence of suitable winter cover, populations can be greatly reduced by floods (Tschaplinski and Hartman, 1983; Mason, 1976).

In Southeast Alaska coastal streams, habitat for juveniles is formed by the hydraulic action of water plunging over or moving around large organic debris (LOD) such as logs or root boles. The cutting action of the stream scours out pools and provides quiet areas free from current velocity. About 70% of the stream habitat structures that are used by juveniles are formed by the influence of LOD (Murphy and Koski, in press; Elliott, unpublished) making it the single most important feature characterizing rearing salmonid habitat. Timber harvest affects summer and winter habitat in several ways: 1) mechanical removal of LOD and destruction of undercut banks, 2) overcleaning by stream clearance crews, and 3) promotes the growth of streamside vegetation. Cross-stream yarding dislodges and destabilizes in-stream debris, often moving it to near-shore areas. Yarding of logs parallel to, or up stream channels, is particularly destructive. Removal of logging residue, even by experienced crews, frequently overcleans streams and much natural debris is removed in the process (Murphy and Koski, in press). This, however, appears to be site specific, as Elliott (unpublished) found no significant difference in the amount of debris in a sample of logged and forested streams of the northern Tongass forest.

Cutting and yarding operations collapse undercut banks, eliminating valuable cover for juveniles. Murphy and Koski (in press) and Elliott (unpublished) have found undercut bank habitat to be only half as frequent after logging. Streamside logging destabilizes undercuts, which contributes to their collapse during freshets and resultant reduction in coho abundance (Tschaplinski and Hartman, 1983).

Removal of the forest canopy stimulates profuse growth of streamside vegetation. Though vegetation can form valuable cover for juveniles, especially when it overhangs pools or other quiet areas, it is not universally important as cover in all locations. However, overhanging vegetation, especially when in flower, attracts numerous terrestrial insects which contribute to the food supply of juvenile fish (Meehan et al., 1977).

INCREASED FRY PRODUCTION EXAMINED:

Low levels of algal production in forested streams is related to the poor light conditions found under the dense timber canopies (Stockner and Shortreed, 1975). Sunlight penetration increases after clearcutting to the edge of stream banks and, either independently, or coupled with elevated nutrients and temperature, has been shown to increase the primary productivity of small streams (Bormann and Likens, 1970;

Hansmann and Phinney, 1973; Murphy and Koski, in press). Additionally, Murphy and Koski (in press) found a strong correlation between increased algal production in clearcuts and elevated levels of aquatic benthos production. They concluded that these factors are responsible for increased abundance of age-0 coho fry in logged streams, relative to fry abundance in forested streams. These findings corroborate the conclusions of others that density of juveniles may be food limited and that juveniles frequently respond to increases in food supply with an increase in rearing density (McFadden, 1969; Mason and Chapman, 1965; Hunt, 1969). Not only are fry more numerous but they appear to be slightly larger in size (Elliott, unpublished). Increased size is thought to be a response to longer growing seasons rather than increased food supply (Tschaplinski and Hartman, 1983; Scrivener and Andersen, 1984).

These recent findings have been seized and promoted by some as evidence that logging is beneficial to the production of salmonids. This is not the case; there is no conclusive evidence that "enrichment" of streams after logging improves stock abundance.

Fry populations in pristine settings can be extremely ephemeral, sometimes rapidly decreasing in number during their first year in fresh water (Chapman, 1965; Crone and Bond, 1976). As they grow, demands for food and space increase and populations adjust by decreasing their density, usually through emigration of the least fit individuals (Chapman, 1966). However, when food is abundant relative to fry recruitment, space requirements decrease (McFadden, 1969; Mason, 1976) permitting higher densities of fry, a condition that has been observed in Oregon clearcuts (Murphy and Hall, 1981) and in Southeast Alaska clearcuts (Murphy and Koski, in press). Experiments by Mason (1976) demonstrated that supplemental feedings of fry increases the number and biomass of coho fry by 6-7 times that found in natural streams. However, he showed that the increased number of coho do not survive the winter and emigrate (during fall-winter floods) due to the lack of suitable winter cover required to support the population at elevated levels. Mason (1976) concluded that "a 6-7 fold increase in potential smolt yield induced by a supplemental feeding strategy during the summer was nullified by the natural carrying capacity of the stream over winter".

This is further supported by findings that habitat used during the summer, which can support large numbers of fish, is not necessarily beneficial during the winter. The behavior of juvenile coho salmon changes at the onset of fall and they move deeper in pools and to recesses provided by LOD (Bustard and Narver, 1975a).

The amount and quality of LOD is probably the most critical factor in determining the suitability of winter habitat; Heifetz et al. (in press) showed that habitat with LOD is used extensively by wintering coho and steelhead but the same types of habitat without LOD are not used. Thus, the above findings strongly suggest that winter habitat is limited to stream structures with specific characteristics and that smolt yield is directly related to the amount of winter habitat.

Furthermore, though clearcutting may produce an abundance of fry during the summer, there is no evidence and no guarantee that these fish will survive and contribute to smolt yield over and above that dictated by winter habitat.

CHANNEL MORPHOLOGY

Because logging debris is more densely concentrated (up to seven times) than most natural accumulations, it can severely constrict flows. The results may be rapid stream bed and stream bank cutting and destabilization of all woody material (Bryant, 1983). When logging debris enters a stream, it is loose and floats easily. Thus, it will move in channels during floods, and dislodge more stable accumulations, release sediment, and increase channel instability. Large concentrations of unstable material can have adverse effects on channel morphology and the general suitability of streams for salmonid spawning and rearing. As organic material and sediment shift along the stream, gravel bars are formed, erosion occurs around piles of large organic debris, and channels become unstable. Heavy loading of debris in streams of more than 10% gradient can cause debris torrents that scour out entire channels and deposit massive jams downstream.

Additional effects of large woody debris on stream channel morphology were discussed by Swanson et al. (1977) and Bryant (1980) for Southeast Alaska streams. These effects include long-term changes in sediment storage, direction of flow, and heterogeneity of stream channels.

LONG TERM EFFECTS ON FISH

ENERGY SOURCES:

In forested streams where there is little sunlight, energy enters aquatic communities from leaves, twigs, needles, etc., which also provide sources of carbon, nitrogen, and other nutrients. Organic particulates are consumed by aquatic invertebrates, which in turn are consumed by juvenile salmonids. This process (heterotrophic energy pathway) occurs to a greater degree in headwater sections of streams where light penetration is poor, but in downstream sections of streams, where the canopy is more divided, permitting more light to reach the water, stream communities utilize a mixture of autotrophic and heterotrophic energy pathways. In other words, energy is accumulated via photosynthetic (light fixing) processes and from organisms extracting energy from fine particulate detritus transported downstream from headwater sections.

Clearcutting shifts the energetic character of headwater sections to that which is more representative of downstream sections. This shift, however, occurs without the benefit of upstream carbon input and could, therefore, affect the diversity of aquatic communities and their functions. It is not known how these effects will impact fish communities, but it is presumed that community function will gradually revert to a more pre-logged condition after 40 to 60 years, when the second growth forest develops along the stream margins.

INSTREAM WOODY DEBRIS

Woody debris from forest sources is a critical feature of stream habitat in coastal Alaska and provides foraging and refuge sites for juveniles during summer and protection against floods during winter. Long-term changes may occur in the quality and quantity of LOD and LOD-formed habitat after clearcutting. Natural stream processes such as mechanical abrasion, biological activity, and especially floods, gradually reduce and transport woody debris downstream. In forested streams, the downstream transport and replacement from the forest through windthrow, etc. is a continuous cycle and debris formed habitat remains at relatively constant levels over time. But where streams have been clearcut, the source of debris is eliminated and stream processes, uninterrupted, will continue to remove debris but will do so without replacement. Using data from old forest fires, Swanson and Lienkaemper (1978) estimated that debris gradually disappears from streams, and that after 110 years, instream debris is reduced to 50% of former levels.

Second growth forests begin to contribute debris at about 110 years and debris loading is estimated to return to natural levels by 150+ years after source removal. Sedell and Triska (1977) suggest an even slower rate of debris accumulation in streams. They found that accumulation of debris is asymptotic and requires about 450 years to recover to natural levels in streams where all native material was removed.

The rate at which stream processes remove debris is unknown. Decay and removal rates in freshwater appear to be very slow because of low biological activity. Even on land, where decay rates are more rapid, downed logs can last from 100-200 years and large logs have been found that have been on the ground for more than 450 years. The rate of removal in streams is probably dependent on stream size as material may be very persistent in small channels but more temporary in large channels.

Rearing salmonids are strongly associated with LOD and LOD-formed habitat. This relationship permits the calculation of the density of juveniles per volume of LOD with fair accuracy. Assuming a maximum loss of 50% of LOD in the first 110 years after clearcutting, equations developed by Elliott (unpublished) predict a loss of about 30% carrying capacity for juvenile coho during the summer. Since juveniles are even more strongly associated with LOD during winter (Heifetz et al., in press) the total loss in annual carrying capacity could be as high as 50%.

If left to themselves after clearcutting, streams will in time gradually repair themselves. However, by 110-150 years after the first cutting, the forest will again be ready for harvest. This will occur at a time when instream debris may not have recovered sufficiently to support optimum densities of juveniles. The result of this scenario is a gradual and perhaps permanent debilitation of stream habitat and a decrease in the yield of salmonid smolt.

EFFECTS OF TIMBER HARVEST ON THE RECREATIONAL USE OF FISH

Changes in Use Patterns

Recreational Use

Since large scale logging began in the late 1950's, there has been a continual reduction in the number of unaltered watersheds available for recreation. Between 1974 and the present, an estimated 1,500 miles of road were scheduled for construction and 107,240 acres of forest designated for clearcutting. This action has made an estimated 900,000 acres of the Tongass National Forest unsuitable for wilderness or roadless recreation. These estimates do not include areas harvested prior to 1974 because data are unavailable. However, best estimates indicate that the pre-1974 figures at least equal those for the 1974-to-present period.

Anglers in Southeast Alaska prefer fishing in an undisturbed, uncrowded environment (Schwan, 1984). As the extent of logging spreads, the opportunity for this type of experience will diminish. Nearly all of the drainages north of Craig and Klawock, on Prince of Wales Island, with the exception of the Karta River, are now logged or have roads. In the Petersburg area, most of northern Kuiu, western Kupreanof, and much of Mitkof Island will be affected. This includes the three best anadromous cutthroat streams in Southeast, Kadake Creek, Hamilton River, and Castle River. Every major drainage north of Sitka, in Peril Strait, Tenakee Inlet, and the northern portion of Chichagof Island west to Port Frederick, will be developed.

According to the Tongass Land Management Plan (TLMP), about 50% of the best salmonid producing streams were scheduled for timber harvest. Fortunately, many of the high value sport fishing systems are now within the boundaries of wilderness areas and are less vulnerable to future development. However, a large number of streams currently in Land Use Designation (LUD) I's and II's could be reclassified to LUD III's and IV's when TLMP is revised. This would make the timber adjacent to many of these streams available for harvest.

Timber development of the Tongass can have a direct effect on harvest rates of salmonids and the displacement of traditional users in some areas. Recreational angling in the immediate vicinity of logging and Forest Service camps can be extremely intense. Nearly half the seasonal take of steelhead at Sitkoh Creek in past years has been by off duty Forest Service personnel and reports from the field indicated that both Forest Service employees and workers from the Corner Bay logging camp have placed extreme pressure on the Kadashan steelhead population. When the Rodman Bay camp was active, tag return data showed that residents of that camp harvested over 50% of the potential Dolly Varden spawners in Rodman Creek during 1 year. Residents of the Rowan Bay camp place heavy demands on sockeye and other freshwater species in Kutlaku Lake.

Road systems in the Tongass are now developed to the extent that links between strategic areas will open up an inter-island highway system. Road networks on Prince of Wales Island and northern Chichagof will eventually create access to over 40 major watersheds. Both networks are accessible by ferries of the Marine Highway System.

The forest road system will provide new opportunities for the use of previously unaccessible areas and distribute fishing pressure to a greater extent. But opening new areas can also bring problems, as many small streams have fish stocks which cannot sustain much fishing pressure, and will likely be overharvested unless there is appropriate regulatory action.

The Alaska Public Survey, conducted in the spring of 1979, showed the importance of the resources of Southeast Alaska to the residents of the region (Alves, 1981). The survey indicated that, for many people, the environmental setting and recreational opportunities was a bigger factor for living in the region than were the economic opportunities provided by the region's natural resources. The survey also attempted to assess the sensitivity of recreators to changes in their favorite places for overnight recreation. A large percentage of all respondents indicates they would stop going to their favorite place if any number of development related activities took place there. The two most detrimental changes were (1) more recreationists and (2) new logging.

Commercial Use

The overall supply of salmon is rooted in the year class survival resulting in an adult return in excess of spawning needs. Current Commercial Fisheries management strategies harvest salmon normally in a mixed stock condition, so that it is virtually impossible to assess reduction in salmon harvest from environmentally induced mortality due to site specific stream effects. (Commercial Fisheries Division staff will be expanding this section.)

Economic Effects - Sport Fishery

Economic effects on recreational anglers from timber harvest activities have not been studied, and in fact the current economic value of the recreational fishery of Southeast Alaska has not been adequately inventoried. It can only be roughly estimated from data collected over a decade ago. Schmidt and Robards (1974), Harmer (1974), and the Department of the Interior (1980) have presented estimates of expenditures related to recreational fishing in Alaska, but only Harmer (1974) estimated an average annual expenditure by a Southeast angler which included expenditures for boats. Harmer estimated the average total expenditure during 1973 by a Southeast angler to be 415 dollars. Mills (1984) estimated 31,671 recreational anglers fished in Southeast Alaska in 1983. By inflating the 1973 expenditures to 1983 dollars (Anchorage based CPI; July, 1983), then roughly 29 million dollars worth of expenditures were made by recreational anglers during 1983.

The Department of Fish and Game is badly in need of detailed, current economic data pertaining to recreational fisheries. Only then can the economic magnitude of the recreational fishery be seen in its proper perspective and economic effects on the fishery from unrelated activities be assessed.

Economic Effects - Commercial Fisheries

True supply - demand, or marked economics, probably do not have an effect on salmon habitat protection or maintenance. Most efforts at maintaining habitat, as far as efficiency of economics is concerned, is an allocation function outside of the market mechanism and is classed as a "social good" left mainly to governmental control (Glass, 1984).

The economic impacts of habitat loss are not represented in the literature concerning salmon production. However, the commercial fisheries manager for the Ketchikan management area stated that he has kept the fishing area associated with Harris River closed to fishing and has succeeded in only achieving adequate escapement of pink salmon into this old logged watershed. He feels that some ecological aspect of the stream has changed that now limits production.

The Department of Fish and Game is called upon to accept "trade-offs" during planning of multiple use management. The problem, with siltation, as just one example, in a "trade-off" decision, is that no estimate of the percentage of loss to the fishery resource can be quantified in either numbers of fish or economic opportunity.

RECOMMENDATIONS

Recommendations will be written after other sections of the 706(b) draft report have been reviewed.

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Prepared by:

Mark W. Schwan
Fishery Biologist

Approved by:

E. Richard Logan, Ph.D., Director
Division of Sport Fish

Louis S. Bandirola, Deputy Director
Division of Sport Fish